HABITAT CONDITIONS

Historically, the Army Corps of Engineers (COE) maintained the Gasconade River for navigation from the mouth of the river to Jerome, Missouri, or approximately 104 miles of stream (Missouri Department of Natural Resources 1986). According to the Missouri Water Atlas (1986), the Gasconade River has no altered segments, meaning it has been neither channelized nor impounded. The Osage Fork of the Gasconade River is also listed as having no altered segments.

Accelerated stream channel changes are possible consequences of in-channel sand and gravel mining. In-channel mining has the potential to artificially accelerate a stream's natural geomorphic processes by increasing channel slope, water velocity, and sedimentation. A stable stream is in dynamic equilibrium. Gravel improperly removed from a streambed location can result in stream disequilibrium by causing erosion upstream from the nick-point (removal area) and within the nick-point. As the stream seeks new mass-balance equilibrium, the nick-point will eventually erode away and migrate upstream in a process known as "head-cutting" (Patrick, D.M. et al. 1993).

Segments of the Gasconade River and some of its tributaries have been altered by gravel mining activity. Army Corps of Engineer's Regulatory Analysis Management System database, which encompasses the entire Gasconade River watershed, contained 1-25 permits per 11-digit hydrologic unit (COE 1999). The number of sand and gravel site permits was determined for the period of February 1992 - February 1999 (Figure 7). The 8-digit Lower Gasconade River watershed with approximately 500,000 acres had higher densities of permitted sand and gravel sites than the 8-digit Upper Gasconade River watershed with its more than one million acres. Lower gradient and corresponding slower water velocities in the Lower Gasconade River watershed allows more gravel to accumulate in the form of gravel bars, which contributes to the instability of the channel. As demonstrated in the Bourbeuse River Watershed Inventory and Assessment (Blanc 1999), land use and stream reach position in a watershed can influence channel instability; likewise, gravel mining can lead to further stream channel instability. In addition, improperly mined areas may experience side effects that may incur a reclamation liability.

Stream Gravel Mining Recommendations

The MDNR's Land Reclamation Program strongly encourages that commercial instream gravel miners conduct mining in accordance with the Missouri Department of Conservation's *Stream Gravel Mining Removal Guidelines* (Missouri Department of Conservation 1991c). These guidelines give general operational recommendations on how, where, and when instream gravel mining should be conducted in order to minimize effects on habitat and biota.

Some essential elements include confining active mining to unconsolidated bars rather than flowing water, leaving buffers around mined areas, restricting damage to streambanks and bank vegetation, preventing the discharge of petroleum products into water. Another operational guideline states that gravel miners should not remove gravel during certain times in several designated reaches to avoid effects on spawning habitats. Prohibiting instream gravel mining seasonally to protect critical spawning habitat is usually incorporated into permits issued by the Army Corps of Engineers for restrictions regulated under Section 404 of the Clean Water Act or by MDNR under Section 401 of the Clean Water Act. Specifically within the Gasconade River watershed, MDC recommends gravel miners observe seasonal spawning closures within the following times and streams:

- 1) November 15 to February 15--
- ! Little Piney Creek, from the mouth of Beaver Creek to the first crossing of Dent County line (Section (S) 16, Township (T) 35N, Range (R) 8W) for 15.8 miles to protect trout spawning habitat,
- ! Mill Creek, from the mouth (S20, T37N, R9W) to the mouth of Deep Hollow Creek (S32, T36N, R9W) for 9.0 miles to protect trout spawning habitat,
- ! Roubidoux Creek, from the mouth (S14, T36N, R12W) to East Section Line (S6, T35N, R11W) to protect a MDC trout management area; and
- 2) March 15 to June 15--
- ! Roubidoux Creek, from the south section line (S3, T34N, R12W) to Highway 32 (S2, T32N, R12W) for 20.2 miles, to protect critical habitat of sensitive endemic aquatic species.

The Missouri Natural Features Inventories are completed for Phelps, Laclede, Pulaski (Ryan 1992), Gasconade, Maries (Currier 1991), Texas, and Wright (Ryan 1993) counties. The objective of the MDC statewide Natural Features Inventory objective was to locate, describe, classify, and rank high quality elements of Missouri's natural habitat. With this knowledge, Missourians protect the state's outstanding features through inclusion in the state natural-areas system, by voluntary landowner agreements, or by allowing informed decisions in sensitive areas.

Within counties of the Gasconade River watershed, identifying sites and adjacent areas involved surveying seven categories: *natural communities* (undisturbed assemblages of plants and animals), *state-listed species habitats* (rare and endangered species), *habitats of relict species*, *outstanding geologic features*, *areas for nature studies*, *other unique features*, and *aquatic communities*. The natural community, geologic feature, and aquatic community sites were further classified using the Terrestrial Natural Communities of Missouri (Nelson 1987), the Geologic Natural Feature Classification System for Missouri (Hebrank 1989), and the Aquatic Community Classification System for Missouri (Pflieger 1989). Following the classification, biologists graded sites for their natural quality, and ranked sites to provide a means of comparing similar features for the preservation value (Currier 1991; Ryan 1992, 1993). Ranking assignments were: significant, exceptional, and notable. According to Ryan (1992, 1993) and Currier (1991), areas that he defined as significant natural features should receive a form of protection (possible inclusion in the Missouri natural areas system), and areas that he defined as exceptional were not of natural area quality but deserving of some protection. Lastly, notable areas on private land did not merit special management or protection.

The focus of this inventory was to identify high-quality natural communities. In the Currier (1991) survey, Spring Creek Gap Glades Natural Area, owned by MDC and located within Spring Creek Gap Conservation Area (Figure 9), was ranked as significant. The site is 12 acres but is considered the best glade system on Jefferson City Cotter dolomite in the upper Ozarks. The Clifty Creek Natural Area, located within the Clifty Creek Conservation Area, contains exceptional limestone and dolomite cliffs, notable sandstone forests, and a rare dry-mesic chert forest. The entire natural area is ranked as significant.

A total of 14 significant natural communities was identified in the Ryan (1992) survey. In fact, several of these communities were found within a few miles of each other. The US Forest Service (USFS) owns two sandstone glades that are located in Phelps County. The first sandstone glade is a string of glades

within close proximity of each other. The second glade, the Kaintuck Hollow sandstone glade, is about 2.5 acres and is near several rare species, an unique forest, and a deep muck fen (Table 18). Contained near this site is an exceptional 15-acre dry-mesic sandstone forests with 100-year-old pines. The deep muck fen, Kaintuck Hollow Fen, is about 10 acres in size but is low quality. The largest of these communities, a mesic bottomland forest, is found on private land and is 30 acres.

Aquatic communities were ranked based on recommendation from William Pflieger of Missouri Department of Conservation (Currier 1991). Currier (1991) commented that the Gasconade River is one of the few unimpounded rivers in the Ozarks and is one of only three rivers in the Mississippi Valley where the anadromous Alabama shad still spawns. Currier (1989) surveyed the Webster County portion of the Osage Fork of the Gasconade River and ranked it as a significant Ozark-Missouri headwater creek and small river that supports numerous sensitive species. In Ryan's 1992 survey of Laclede, Phelps, and Pulaski counties, Little Piney Creek was identified as a notable creek and small river, and Gasconade River and Osage Fork of the Gasconade River were identified as significant small rivers. Multiple sections of the Gasconade River from T37N to T38N, R9W to R10W were listed as a significant large river. In the Ryan (1991) survey of Texas County, Ryan mentioned Roubidoux Creek (T31N-T33N, R11W-R12W) as a significant small creek and headwater Ozark-Missouri stream, supporting a diverse fish fauna. In the same survey of Webster County, once again the Gasconade River was mentioned as a significant large river with numerous endemic fish species. Other portions of the Gasconade River watershed were described in the Natural Features Inventories, some mentioning heron rookeries and others, backwater pools.

Ryan (1992) described other special aquatic communities in the survey. Pulaski County has a large number of springs (Figure 10) and caves. These include two spring branches, Howell Spring and Prewett Spring, and two springs, Boiling Spring and Roubidoux Spring. Ryan noted no disturbance at Howell Spring and moderate plant diversity, but Prewett Spring was grazed. The solution cave was an added feature of the Howell Spring community. Another cave that has a small population of *Myotis sodalis* is Great Spirit Cave, owned by Missouri Department of Conservation. A slough in Pulaski County was described as having 0.6 miles of the old river channel, cliffs, a spring, and wooded streambanks.

One purpose of these surveys was to rank bottomland forests within the respective counties. No bottomland forests were surveyed in the Gasconade River watershed portion of Texas and Wright counties or Webster County, but in the Gasconade River watershed portion, bottomland forests were surveyed in Gasconade, Maries, and Osage counties, three in each county. Only eight bottomland forests were surveyed in the Laclede County, Phelps County, and Pulaski County Natural Features Inventory. Most bottomland forests were mesic bottomland forest of young to mature second growth and not high quality. Within the Gasconade, Maries and Osage county surveys these bottomland forests were mid-successional and moderately to heavily disturbed communities, which may have included moderate recent disturbance or heavy past disturbance. The sizes ranged from seven to 40 acres. Within the Laclede, Phelps, and Pulaski county surveys, three of the eight survey sites were lightly or heavily grazed. Three of the eight survey sites were recently logged. One of the eight survey sites was the Strawhaun Bottomland Forest that was ranked as significant.

The habitats of some state-listed species are found on sites within the watershed. These sites are identified as information becomes available. Individual state-listed species that located in the watershed are identified in the Rare and Endangered Species subsection.

To control streambank erosion, improve water quality, and establish fish habitat, MDC fisheries biologists use cedar tree revetments, corridor reforestation, streambank re-vegetation, willow staking, and rock blankets (riprap). Table 19 lists some projects in the Gasconade River watershed that make use of these techniques. Eight of the stream improvement sites used the cedar tree revetment technique to stabilize streambank. Cedar tree revetment involves the use of eastern red cedar trees anchored along a streambank to protect the toe of the bank and to slow water velocity (Fantz et al. 1993). This low cost bank stabilization technique involves using refined methodology that must be tailored to the erosion site. Not all streambank erosion sites are conducive to cedar tree revetments because of watershed influences. The numerous projects on Mill Creek make use of a variety of techniques to stabilize streambanks and provide instream habitat on Forest Service as well as private land.

Corridor improvements are an important part of streambank erosion reduction and fish habitat enhancement. The future ecological benefits to the aquatic community are reduced sediment supply, shade from the sun, temperature reductions, and leaf litter inputs for the aquatic food web.

Stream Habitat Assessment

Corridor Conditions

Using Arc/Info (Environmental Systems Research Institute's Geographic Information Systems software), the Gasconade River 1:100,000 scale stream network, and Missouri Resource Assessment Partnership's (MORAP 1997) Phase II Land Use / Land Cover (LULC) individual stream segments were classified by the percentages of surrounding land use types (for GIS methodology contact the Missouri Department of Conservation). For example, stream segments were classified by the ranges of the percentage of the forest class contained within the stream buffer area to identify those segments that had the highest probability of direct exposure of forest to stream a channel (Figure 18 and 20). To highlight the forested corridors within the Lower Gasconade River watershed, the lowest and the highest percentage of forested corridors was, respectively, the Lower Gasconade 11-digit HU at 48.8% and the 11-digit Lower Gasconade River Hills at 55.3%. Values within the Lower Gasconade River HU were probably somewhat higher than the 20-40% forested corridor presented, because within this 90-meter buffer the 8-digit Lower Gasconade River watershed had approximately 5% of the pixels as water (Figure 18). LULC satellite imagery was dated 1992-93 during years of high water, which likely influenced the resulting forested segments.

The entire 8-digit Upper Gasconade River watershed was poorly forested along major segments of its tributaries and main stem compared to the 8-digit Lower Gasconade River watershed (Table 20 and Figure 20). A total of 38.2% of the major segments (main stem river and tributaries segments with permanent flow) within the Upper Gasconade had forested corridors, and 46.1% of the major segments in the Lower Gasconade supported forested corridors. To highlight the forested corridors in the Upper Gasconade River watershed, the lowest and highest percentages were the 11-digit Upper Osage River HU at 38.5% forested corridor and the 11-digit Upper Gasconade River HU at 48.9% forested corridor, which was a spread of 10.4% (Table 20). The Mark Twain National Forest influences the quantity of forested corridors within the 11-digit Upper Gasconade River HU. In reality, its corridor quality was good in comparison to other watersheds (Figure 21).

Corridor quality was determined to assess the stream segments within 11-digit hydrologic units (Figure 19 and Figure 21). While many factors impact the quality of the corridor, stream channel stability, and water quality, forest and woodland land uses improve stream quality because of their soil holding

capacity, where as grassland, cropland, and urban land uses do not improve stream water quality (Jacobson and Primm 1994; Blanc, Caldwell, and Hawks 1998). Grassland, cropland, and urban areas are known to have higher soil erosion and runoff rates. To determine where land uses were influencing corridor quality, the following ratio was developed:

(% grassland and cropland and urban)/(% forest and woodland).

The quality of a stream corridor varied as the sum of the percentage of forest and woodland changed with respect to the changes in the sum of grassland, cropland, and urban. As values of the numerator increased and the denominator decreased, the quality of the corridor within the buffer zone declined. These areas were shown as the "poor" ratio values from 5-100%. Conversely, within a 90-meter buffer zone, as grassland and cropland declined and forest corridor increased, this translated into better quality corridors. More poor quality stream segments were found in the tributaries to major order segments. An "acceptable" corridor had, depending on the stream order, 15-35 meters of corridor (Wehnes 1996), which was approximately 17-40 % or greater forest and woodland within the buffer zone. Hence, the quality ratio of "acceptable" had to be within the range of 1.5-5. A quality ratio value of 0.0-1.49 had better corridor conditions and were rated as "good."

The results of the quality ratio show the differences between the 8-digit Upper Gasconade River watershed and the 8-digit Lower Gasconade River watershed. Using the limitations of the 1:100,000 scale stream network, which did not have many 1st- and 2nd-order streams, stream segments within the Lower Gasconade River watershed had 81% (6,752) as good (quality ratio range of 0.0-1.49), another 12.5% (1,041) as acceptable, and the remaining 0.6% (526) of the segments as poor. There were 8,319 stream segments within the Lower Gasconade River watershed and 14,404 stream segments within the Upper Gasconade River watershed that had an average length of 361 meters. The Lower Gasconade River watershed had more good quality segments than the Upper Gasconade River watershed, which had 63.8% (9,199) rated as good, 17.5% (2,518) as acceptable, and the remaining 18.7% (2,687) segments as poor.

Several 11-digit hydrologic units could be targeted for private lands incentive programs. Lower Gasconade River HU below Highway 68 Bridge and the confluence with Spring Creek could be targeted for stream incentive programs (Figure 19). The upper portion of the main stem Little Piney Creek HU has much cropland and grassland that should be surveyed for possible restoration. Third Creek HU has some troubled tributaries that need attention. Second Creek within the Lower Gasconade River Hills has stream segments near the confluence with the main stem Gasconade River that may need attention. Roubidoux Creek HU has in the past received attention but does merit further emphasis because of its unique combination of land uses (Figure 21). The water quality challenges within this watershed were identified by Imes et al. (1996) in the USGS water quality assessment of the Fort Leonard Wood military base. Groundwater resources are particularly sensitive in this region of the Upper Gasconade River watershed. Within the Upper Gasconade River Tributaries HU, Whetstone Creek and Woods Fork had stream segments with extreme amounts of grassland land uses. Forested corridor was limited in selected portions of both Whetstone Creek and Woods Fork (Figure 21).

Identifying other degraded or healthy streams, narrowing the list of potential causes of degradation within stream segments, and selecting the most pristine or degraded reaches will be done interactively within ArcView by MDC East Central Region personnel. Measures to be taken by personnel within the Gasconade River watershed to improve riparian corridors include offering financial assistance to help

landowners fence cattle from riparian corridors and re-vegetate riparian zones. Studies have shown that fencing cattle from a stream and its riparian corridor can reduce soil losses (Ownes et al. 1996, Magilligan and McDowell 1997). Researchers observed two consistent stream channel changes with the restoration of riparian corridor: a decrease in channel widths and development of more channel pools. The researchers concluded that the regrowth of streambank vegetation added stream channel roughness, which increased channel scour holes or pools during floods.

Land Use Conditions

Using Arc/Info Geographic Information Systems (GIS), MORAP Phase II Land Use / Land Cover (LULC) Classification and the Gasconade River watershed boundaries were combined (for GIS methodology contact the Missouri Department of Conservation). A rating system was developed to determine the overall impact of land uses to the each hydrologic unit within the Upper and Lower Gasconade River watersheds. Beneficial to stream health were the forest and woodland classes, because watershed roughness components from vegetative land cover were a vital part of the stream's erosion protection and the water filtering capacity. Also, the forest and the woodland classes were land uses that were positively correlated with biotic integrity (Wang et al. 1997). These percentages were added to make another field called percentage of forest and woodland. Other classes such as urban and cropland tend to have detrimental effects on stream habitat and water quality. Likewise, these percentages were added to make an additional field called percentage of urban and cropland. These combined percentages are negatively correlated with biotic integrity (Wang et al. 1997). The urban and cropland land uses were subtracted from the percentage of forest and woodland to obtain a third field, called impacted. Working with the resulting range of values, the highest value was given a value of "100" and the lowest, a value of "zero." The value of "zero" represented the most impacted area and the value of "100," the least impacted. A range of rating values was developed from this third field range, impacted, and subsequently assigned to the remaining impacted values (Table 21).

Hydrologic Unit LULC Ratings

Within Upper and Lower Gasconade River watersheds, the percentage of forest and woodland and percentage of urban and cropland for each 14-digit hydrologic unit provided a means of comparing among HUs (Table 21). The three highest ratings and three lowest ratings were compiled in Table 21 for each 8-digit watershed.

These ratings provided a useful means of assessing the watershed and gave insight to potential problem areas to be better managed with the best available practices. Hydrologic units that have poor ratings can be earmarked for further investigation, and landowners within these units targeted for possible landowner incentive programs.

Within the Upper Gasconade River watershed (Table 22), averaging all 14-digit HUs within each 11-digit HU indicated that the Middle Gasconade River HU had the highest mean value of 85.91. The Roubidoux Creek HU had the lowest average rating because two of its 14-digit HUs had relatively low ratings. However, the Roubidoux Creek 11-digit HU had the third highest rating 14-digit HU within the 8-digit Upper Gasconade River watershed (Table 22; 95.9). Sections of the upper Roubidoux were within the Mark Twain National Forest and the private holdings were forest or woodland land use, which explains the higher 14-digit rating. The Upper Osage Fork had a fairly low rating that may merit attention given its present status as a NRCS Conservation Priority Area to target water quality problems (Missouri Unified Watershed Assessment Steering Committee 1998). While the Upper Gasconade River

Tributaries HU rates as a relatively pristine environment due to the presence of the Mark Twain National Forest, the Upper Gasconade River HU was more impacted. In fact, areas within the 11-digit Upper Gasconade River HU are NRCS Conservation Priority Areas (Missouri Unified Watershed Assessment Steering Committee 1998). Within the Lower Gasconade River watershed (Table 23), averaging all 14-digit HUs within each 11-digit HU indicated that the Little Piney Creek HU had the highest mean rating of 70.10. The lowest mean value of 48.11 was found in the Lower Gasconade River HU.

Based on this analysis, priority for improvement should be given to those hydrologic units that were rated low. The Lower Gasconade River HU (#10290203-020) was rated poor due to the lack of forested stream corridor (Table 23). But the present land use information may have under-represented the amount of forest in that HU, however no other information is available. A cross referencing with helicopter videos (Missouri Department of Conservation 1993) of the Lower Gasconade HU, filmed from the confluence with Little Piney Creek down Paydown Access on the Gasconade River, showed that, in general, the corridor varied from forested areas intermixed with pastured areas to one or two rows of trees progressing toward Paydown Access. These narrow corridors may not have been detected by image analysis. Still, the results showed that relative to other HUs, the Lower Gasconade River HU remained in poorer condition. An additional HU, the Lower Roubidoux Creek HU, should be given priority management attention because of its sensitive springs and fisheries (Figure 10) and the presence of a growing human population (Figure 7).

Erosion and Deposition

Contributions of woody vegetation to streambank stability and to stream energy dissipation have been supported by researchers (McKenney, Jacobson, and Wertheimer 1995). Woody vegetation imparts overall strength to the streambed and streambank and greater erosion resistance, and as a result, greater channel stability. Based on this information, land and stream managers have advocated increased stream corridor widths and densities of streamside vegetation to decrease streambank erosion (Missouri Department of Conservation 1997; Reno, Pulliam, and Priesendorf 1995; Roell 1994). Recent photogrammetric/GIS studies on Little Piney Creek (a 12-kilometer 5th-order segment extending from, approximately, Yancy Mills to Hickory Point) have determined that the benefits derived from vegetation in the maintenance and recovery of stream channels were influenced by watershedwide factors and land cover and land use characteristics of individual reaches (Jacobson and Pugh 1997). In this GIS analysis, Jacobson and Pugh assumed that woodland had a greater chance of being eroded than grassland/cropland, which were positioned farther away from the stream channel. To determine erosion and deposition susceptibility of the Little Piney Creek study segment, Jacobson and Pugh performed calculations in a digital GIS format using a polygon identity map (intersection of two maps) from each pair of successive maps, i.e., transition periods 1938-48, 1948-55, 1955-64, 1964-76, and 1976-89. Jacobson and Pugh (1997) concluded that the results of their GIS analysis were applicable to other 4th -6th order Ozark streams with similar physiographic controls and land use histories.

Evidence presented in Jacobson and Primm (1994) supports the theory that streams were destabilized by historic land-use practices and their present state of instability is the result of decreased riparian vegetation. The results of the GIS analysis performed by Jacobson and Pugh (1997) indicate that erosion or deposition susceptibilities are not solely controlled by riparian vegetation. Reaches are susceptible to disturbance by mechanisms such as valley wall geometry, bank height greater than root depth, upstream changes, and sediment size changes, that are quite complex. Finally, Jacobson and Pugh (1997) believe that before a biologist attempts a stream improvement project, as listed in Table 19, he or she should

have additional information on disturbance history, streambank soil cohesion, channel gradient, and if possible, runoff rates and stream bed load.

National Wetland Inventory

The U.S. Fish and Wildlife National Wetland Inventory (NWI) data for the Gasconade River watershed was summarized for like wetland polygons within each hydrologic unit. To interpret the NWI coding system, several sources were used. Translating the wetland types from the Cowardin System (Cowardin et al. 1979) to the Missouri Wetland system was done with the aid of the Epperson (1992) (Table 24). A database containing the all polygonal (the cartographic representation of a wetland's geometry) wetland types, identified using the Cowardin System code, in the Gasconade River watershed was translated into systems, subsystems or classes, modifiers, and descriptions (for GIS methodology contact the Missouri Department of Conservation).

The NWI dataset is the most detailed information available for water bodies. The existing 1:100,000 scale water body file, extracted from the USGS digital line graph files (DLGs), had fewer water bodies represented. The NWI database had a total of 17,795 polygonal wetlands in the Upper Gasconade River watershed and 8,071 polygonal wetlands in the Lower Gasconade River watershed. Percentage of total wetland acres for each wetland system/class and description within the each 8-digit Gasconade River watershed illustrates the distribution of wetland types over the changing topography (Table 25).

Several Riverine subsystems and classes are describing temporary-semipermanent pool within the river. Pools are important for fish population growth and production. In the Upper Gasconade River watershed, 13.1% of the total polygonal wetland acreage (TPWA) are temporary-semipermanent pools (Table 25). Riverine wetlands comprise 54.8% of total wetland acreage in the Upper Gasconade River, representing the largest wetland system. A total of 30% of the TPWA is the pool/riffle complex in the Upper Gasconade River watershed. Because this watershed is the headwater of the Gasconade River, 0.36% is permanent pool.

The predominant wetland types in the Lower Gasconade River watershed are Palustrine. Palustrine wetlands represent the largest wetland system with 43% of the TPWA (Table 25). The lower gradient and larger order stream system has setup conditions for more Palustrine wetlands. The lower watershed has a large percentage (42.4%) of deciduous bottomland forests. Many of these bottomland forests are temporarily or seasonally flooded, which makes them unavailable to cropland conversion without substantial diking. However, many of the wetland polygons have special modifiers identifying them as drained, diked, impounded, or excavated. These modified bottomland areas may be providing a buffer from flooding for cropland that is farther upland. A very large percentage of the total acreage of wetlands in Gasconade River watershed are farm ponds (NWI code: PUBGh, PUBFh), 33.4% for the upper watershed and 28.2% for the lower watershed.

Nursery Wetlands

Mark Caldwell of MDC Fisheries Research used NWI data to identify potential nursery wetlands for fish in the Meramec River Watershed Inventory and Assessment (Blanc, Caldwell, and Hawks 1998). Using the criteria that the classes had to be Palustrine (non-channel, non-lake, perennial, or nearly perennial, and be a natural wetland, i.e., not excavated or impounded) and connected to a perennial stream, he identified polygonal wetlands that had potential to function as fish nursery habitat. A similar procedure was used for the Gasconade River watershed (for GIS methodology contact the Missouri Department of

Conservation).

Overall, total nursery wetland acreage was 107.8 acres for the Upper Gasconade River watershed and 43.8 acres for the Lower Gasconade River watershed. Of the total wetland acreage within the Upper Gasconade River watershed, 0.9% met the nursery wetland criteria, and within the Lower Gasconade River watershed another 0.6% met the criteria. Connectivity to streams was not tested.

Channel Condition

Habitat for fish, especially smallmouth bass, is best where there is good pool development. Using the NWI data sets, several classes of the Riverine system identify stream reaches that have suitable fish habitat. Several Riverine system classes were summarized into the groups that help interpret the Cowardin System code: temporary-semipermanent pool, temporary pool, pool/riffle complex, and permanent pool (Table 27). For instance, grouped into the temporary-semipermanent pool description, the R3UBF, R3UBG, and R2UBG attributed polygons are upper (3) and lower (2) perennial stream segments with 25% of particles smaller than stones, vegetative cover less that 30%, and unstable bottoms that can be sand, mud, gravel or organic materials. As described by Cowardin, L. M. et al. (1979), modifiers F or G describe these habitats as semipermanent flooded or intermittently exposed. These water regime modifiers are an important feature of the wetland classification because they indicate the hydrologic characteristics of the wetland. Indicating how long water stands in the habitat, a Riverine system habitat can be classified within the range temporarily flooded to saturated to intermittently exposed to permanently flooded.

Having a more rugged topography and higher gradient than the Lower Gasconade River watershed, the Upper Gasconade River watershed has 2.56% of the total polygonal wetland acreage as temporary pool, and the Lower Gasconade River watershed has 0.11% as temporary pool (Table 25). This subsystem is intermittent and contains flowing water only part of the year (Cowardin et al. 1979). Intermittently, habitat classified within this subsystem will have temporary pools for extended periods. This habitat type is found within the Upper Osage Fork HU (0.06% TPWA), Roubidoux Creek HU (22% TPWA), and Little Piney Creek HU (0.48% TPWA) of the Upper Gasconade River watershed. To a lesser extent, some tributaries to Little Piney Creek (0.48% TPWA), Lower Gasconade River Hills HU (0.08% TPWA), and Lower Gasconade River Tributaries (0.06% TPWA) have temporary pool habitat. Poor in terms of sport fish habitat, these wetland types are likely to have, at a minimum, frogs and a few non-game fish species.

More acres of permanent habitat types, like the temporary-semipermanent pool, are found within the Upper Gasconade River watershed (13.13%) and fewer acres in the Lower Gasconade River watershed (4.42%). Density of streams is much greater in the upper watershed areas as compared to the lower, which explains the large difference in percentages. All hydrologic units have this habitat type. It represents the largest Riverine habitat. When its percentage of the TPWA is small, a habitat with a permanent water regime is present. The 8-digit Upper Gasconade River watershed had numerous acres of the temporary-semipermanent Riverine pool habitat types that are replaced by a permanent water regime in the form of very long pool/riffe complexes (Table 25). In contrast, the 8-digit Lower Gasconade River watershed had more permanent pools. The largest expanse of the pool/riffle complex habitat was found in the Middle Gasconade River HU (67.4%). Lower gradient and many tributaries lend to the development of this habitat. Somewhat lower in gradient than the Upper Osage Fork HU, the Lower Osage Fork HU had 32.1% of TPWA as pool/riffle complex Riverine habitat. Fifty-seven acres of

permanent pool or 6.26% of TPWA were found in the Little Piney Creek HU. While lower perennial streams of the Lower Gasconade River Hills HU made up 84 acres of the 97 total temporary-semipermanent pool acres, their water regime was not classified as permanent but rather intermittently exposed. Permanent pool became more a feature of the Lower Gasconade River HU with 0.16% of the TPWA.

Gravel Bars

Channel condition of streams within hydrologic units of the Gasconade River watershed was characterized by evaluating the gravel bar status. The total acreage of gravel bars can be a good indicator of overall watershed and stream channel health. Channel stability, as well as fish habitat, is influenced by a variety of factors, such as bed load and gradient.

Channel condition may be poorest in those HUs with a high percentage of gravel bar acres per HU acres. R2USA (Riverine, Lower Perennial Unconsolidated Shore, Unaltered wetland type) and R3USA (Riverine, Upper Perennial Unconsolidated Shore, Unaltered wetland type) were represented as gravel bars in the summarization of polygon acreage (Table 26). To compare the quantity of gravel bars between 11-digit hydrologic units (HUs), the total 11-digit unit acreage was used to normalize the gravel bar acreage within each HU. The percentage of gravel bar acres per HU area was highest in three of the eleven 11-digit hydrologic units, Upper Gasconade River Tributaries at 0.149%, Third Creek at 0.149%, and Upper Osage Fork at 0.128%, respectively. Third Creek has the smallest HU area of all 11-digit units but had the highest percentage of gravel bar acres relative to its small size. Upper Gasconade River Tributaries has the fourth smallest HU area and the Upper Osage Fork HU, the third smallest HU area. Other HUs that were larger in size, such as the Upper Gasconade River HU and the Little Piney Creek HU, were low in gravel bar acres, and the Little Piney Creek HU was the lowest in the total gravel bar acreage.

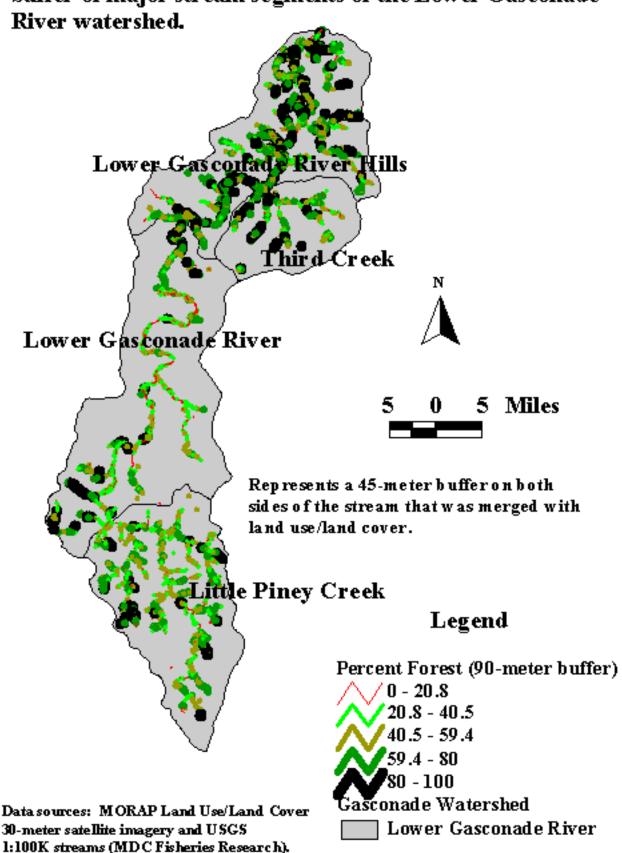
Sources of gravel may not have been from with the tributaries of each HU but from upstream adjoining HUs. The presence of a forested corridor (Table 20) may have contributed to slower water velocity and subsequent bed load deposition. To illustrate, a continuum of gravel bars along the main stem Gasconade River indicated decreases in percentage of gravel bar acres/HU area from the Upper Gasconade River HU (#10290201-010) to the Lower Gasconade River Hills HU (#10290203-040). Within five main stem HUs starting with the Upper Gasconade River HU and ending with the Lower Gasconade River Hills HU, the percentage of gravel bar acres per HU area was 0.041, 0.149, 0.088, 0.081, and 0.077. The total gravel bar acreage in the Upper Gasconade River HU was only 61.2 acres, which was considerably less than those HUs along the river continuum such as the following Upper Gasconade River Tributaries HU with 224.3 acres and the adjoining Middle Gasconade River HU with 136.5 acres. The Upper Gasconade River HU had more land uses that contribute to sediment loading and streambank erosion (see Hydrologic Unit LULC Ratings, Table 21), while the Upper Gasconade River Tributaries HU had mostly forest and woodland land uses – beneficial to streams. The forested corridor areas of the Upper Gasconade River Tributaries may have slowed water velocity and allowed gravel deposition. This suggests that the source of much of the sediment loading to Upper Gasconade River Tributaries HU (LULC rating of 85.9) may be areas within the Upper Gasconade River HU (LULC rating of 59.4), the largest HU of the eleven 11-digit HUs, and possibly from an additional major tributary, Beaver Creek HU (LULC rating of 68.4). Furthermore, the sources may be upland areas because the percentage of forested stream corridors within the Upper Gasconade River HU was the highest within the 8-digit Upper Gasconade River watershed (Table 20). A large number of gravel mining permits were issued for the

Upper Gasconade River HU and Beaver Creek HU (Figure 7), which indicated that gravel was available, and possibly the information contained within the NWI dataset was deficient of those smaller gravel bars less than one-tenth acre in size. These smaller gravel bars would have been common in upper watershed areas. Also, the forested corridor canopy may have made gravel bars invisible to the stereoscopic analysis of the high altitude aerial photographs performed by the National Wetland Inventory.

The several 11-digit units within the 8-digit Upper Gasconade River watershed may be the source of sediment for gravel bars of the Middle Gasconade River HU. The Upper and Lower Osage Fork (61.0 and 66.4, respectively) were rated relatively low in the LULC rating, compared to the Middle Gasconade River watershed (Table 22). Also, these HUs had several acres of gravel bars. Lower in percentage of forested corridor than other HUs, the gravel bars in the Upper and Lower Osage Fork may have been more visible to the stereoscopic analysis of aerial photographs or channel instability was contributing to their presence. Once this sediment load arrived in the Middle Gasconade River HU, the better forested corridor and possibly the drop in channel gradient slowed water velocity and deposited the bed load. Also, a tributary to the Middle Gasconade River HU, Roubidoux Creek, although it scored low in LULC rating, had few gravel bars, which likely may have been attributed to its more stable forested upper watershed.

In conclusion, Jacobson and Primm (1994) support the theory that historic land-use practices destabilized streams and their present state of instability is the result decreased riparian vegetation. Channel stability is not solely controlled by riparian vegetation; other mechanisms such as valley wall geometry and upstream changes can significantly affect channel stability (Jacobson and Pugh 1997). As demonstrated within relatively low impacted HUs with healthy forested stream corridors, potentially healthy channels may be adversely affected by poorer upper watershed conditions. Channel condition and stability are a complex combination of variables, of which several variables, such as those previously mentioned, play an important role.

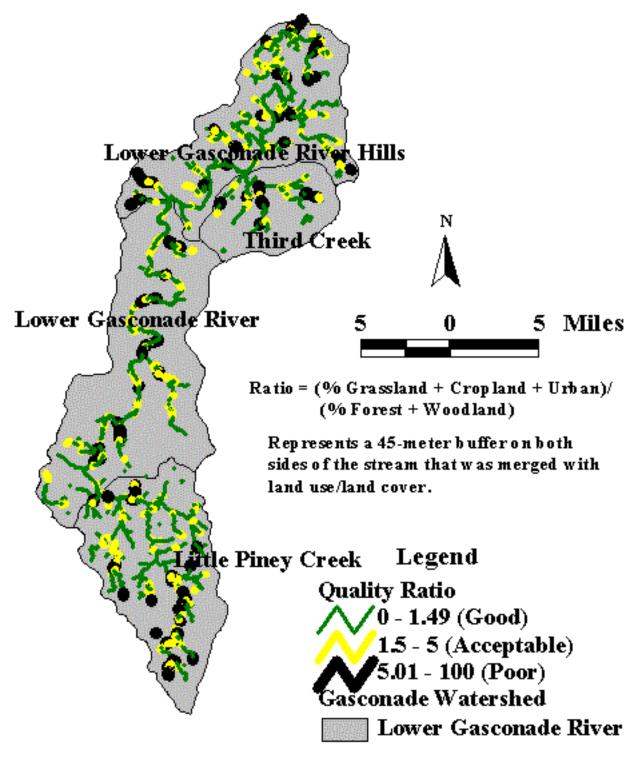
Figure 18. Percent forested corridor within 90-meter buffer of major stream segments of the Lower Gasconade



Map production: Todd Blanc, 1/00

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Figure 19. Corridor quality of major stream segments within 90-meter buffer of the Lower Gasconade River watershed. Based on % land use ratio within buffer.



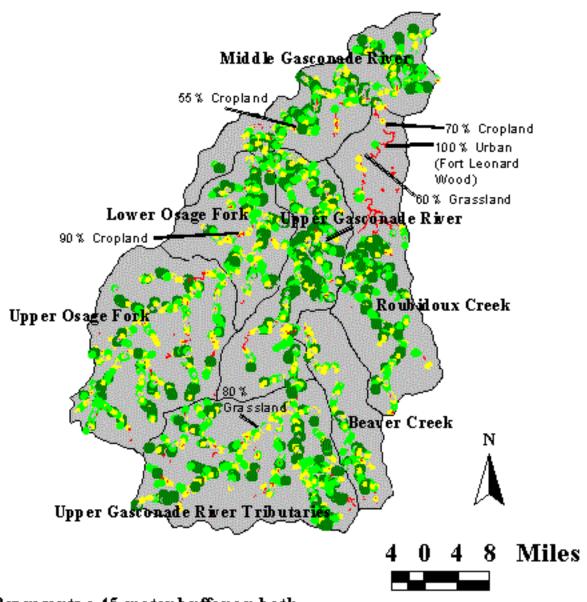
Data sources: MORAP Land Use/Land Cover

30-meter satellite imagery and USGS

1:100K streams (MDC Fisheries Research).

Map production: Todd Blanc, 1/00

Figure 20. Percent forested corridor within a 90-meter buffer of major stream segments of the Upper Gasconade River watershed.



Represents a 45-meter buffer on both sides of the stream that was merged with land use/land cover.

Data sources: MORAP Land Use/Land Cover 30-meter satellite imagery and USGS 1:100K streams (MDC Fisheries Research). Map production: Todd Blanc, 1/00

Legend

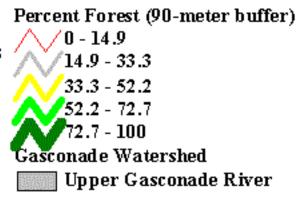
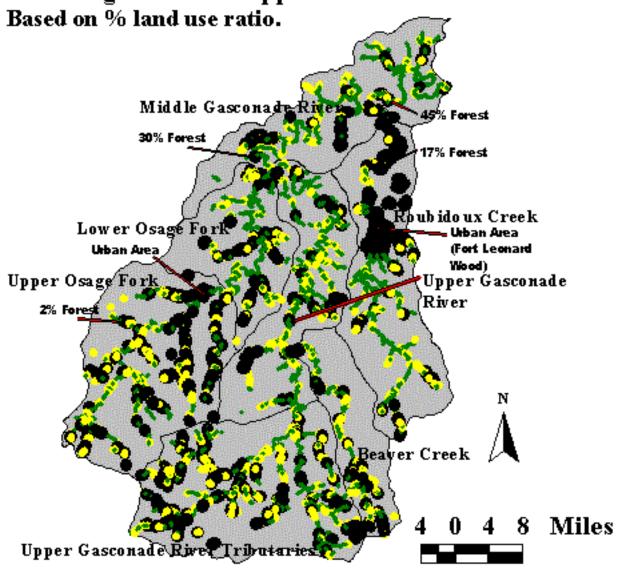


Figure 21. Corridor quality within 90-meter buffer of major stream segments of the Upper Gasconade River watershed.



Legend

Represents a 45-meter buffer on both sides of the stream that was merged with land use/land cover.

Data sources: MORAP Land Use/Land Cover 30-meter satellite imagery and USGS 1:100K streams (MDC Fisheries Research).
Map production: Todd Blanc, 1/00

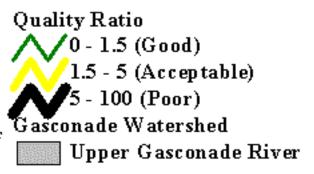


Table 18. Significant natural communities identified in the Natural Features Inventory: Phelps, Pulaski, and Laclede Counties (Ryan 1992).

Site Name and Community	Owner	Size (acres)	Natural Quality ¹
Laclede County			
Mayfield Spring and Wet Meadow Fen	USFS	5	B/C
Flagmire Hollow Fen	USFS	1.5	В
Phelps County			
Hwy. T Forest Dry-Mesic Sandstone Forest	USFS	20	В
Wilkins Spring Fen/Wetland	USFS	4	В
Kaintuck Hollow Sandstone Glade	USFS	2.5	В
Apple Tree Farm Deep Muck Fen	Pvt.	7	B/C
Mill Creek Fen Deep Muck Fen	USFS	1.5	В
Kaintuck Hollow Fen	USFS	10	C/C+
Strawhun Forest Mesic Bottomland Forest	Pvt.	30	В
Solomon Hollow Glades	USFS	3	В

Pulaski County			
Tunnel Cave Influent Cave	Pvt. TNC reg.	-	В
Great Spirit Cave N.H.A. Effluent Cave	MDC	-	В
Falls Hollow Sandstone Glades	DA	4	В
Karen's Fen Fen	USFS	6	В

¹Natural quality:

- A-Relative stable and undisturbed natural community (e.g., old growth, ungrazed forest)
- B-Late successional or lightly disturbed communities; disturbed in past but now recovered; diversity not greatly reduced.
- C-Mid-successional, moderate to heavily disturbed communities; moderate recent disturbance or heavy past disturbance; diversity lowered.
- D-Early successional or severely disturbed communities; structure and composition severely altered.
- E- Original community removed or nearly so (e.g., rowcrop).

Table 19. Description of stream improvement projects in the Gasconade River watershed, Missouri (Missouri Department of Conservation, East Central Region Fisheries, unpublished data).

Stream	Technique/ Program	County Twn-Rng-Sec	Completion	Comments
3 rd Order unnamed trib to Gasconade	cedar tree revetment, willow staking, corridor fencing/ Equipment Loan	Osage T44N R7W S24	1994	Private land
Beaver Creek	cedar tree revetment/ Cost Share	Phelps T37N R8W S33	1991	Private land
Clear Fork	cedar tree revetment/ State Land	Gasconade T41N R5W S4	1994	Canaan CA
Contrary Creek	cedar tree revetment/ Equipment Loan	Osage T43N R8W S23	1991	Private land partially complete
Gasconade River	streambank revegetation/ State Land	Osage T43N R7W S31	1991	Pointer's Creek Access
Little Piney Creek	cedar tree revetment/ Cooperative-USFS	Phelps T37N R9W S36	1991	Little Piney Allotment
Little Piney Creek	cedar tree revetment/ Cost Share	Phelps T37N R9W S25	1994	Private land, project failed
Mill Creek	rootwads & boulders	Phelps T36N R9W S4	1993	USFS Gabel tract

Mill Creek	anchored rootwads/ Cooperative-USFS	Phelps T36N R9W S4	1993	Mill Creek Rec. Area
Mill Creek	cedar tree and rock revetment, rootwads/ Cost Share	Phelps T36N R9W S33	1994	Private land
Mill Creek	rootwads/ Cooperative-USFS/ Trout Unlimited	Phelps T36N R9W S33	1998	USFS Gabel Tract
Mill Creek	rootwads, cedar tree revetment/ Cooperative-USFS/ Trout Unlimited	Phelps T36N R9W S33 & S4	1999	USFS Gabel Tract
Samples Creek	riparian planting/ Cost Share	Phelps T34N R8W S21	1993	Private land
Second Creek	cedar tree revetment ¹ / Equipment Loan	Gasconade T43N R5W S7	1994	Private land

Table 20. Mean % forested corridor within 1:100K 90-meter buffered streams of Gasconade River 11-digit hydrologic units.

11-digit Hydrologic Units (HUs)	Mean %	Mean % of Major Segments ¹
Upper Gasconade River 8-digit HU	42.4	38.2
Upper Gasconade River	48.9	
Upper Gasconade River Tributaries	42.7	
Upper Osage Fork	38.5	
Lower Osage Fork	40.1	
Middle Gasconade River	45.2	
Beaver Creek	44.3	
Roubidoux Creek	38.9	
Lower Gasconade River 8-digit HU	49.6	46.1
Lower Gasconade River Hills	55.3	
Third Creek	54.4	
Lower Gasconade River	44.4	
Little Piney Creek	48.8	

¹ those main stem river and tributaries segments with permanent flow

Table 21. Most and least impacted hydrologic units within the Gasconade River watershed (HUC # 10290201- and 10290203-) determined using Phase II Land Use / Land Cover MORAP 30-meter resolution satellite imagery. Gasconade rating scores the % LULC classes of the Gasconade River HUs according to a derived high and low range.

14-digit Hydrologic	% Forest &	% Urban &	Gasconade Rating
Units	Woodland	Cropland	Gasconauc Rating
Upper Gasconade River	watershed		
-060004	31.31	62.37	0.4
-060005	29.31	57.42	3.99
-010005	38.49	9.28	32.47
-060002	66.70	4.66	95.9
-070005	69.62	4.80	98.9
-050005	68.84	3.93	98.95
Lower Gasconade River	watershed		
-040004	57.63	15.64	2.50
-020003	57.241	13.539	7.10
-020007	53.185	6.57	14.60
-040005	72.961	5.985	83.10
-010005	73.954	10.509	85.70
-010003	82.614	2.831	99.90

Table 22. Impacted 14-digit hydrologic units within the Upper Gasconade River watershed (HUC # 10290201-) determined using Phase II Land Use / Land Cover MORAP 30-meter resolution satellite imagery. Ratings from 0 (most) to 100 (least) impacted. Gasconade rating scores the % LULC classes of the Gasconade River HUs according to a derived high and low range.

14-digit Hydrologic	% Forest &	% Urban &	Gasconade Rating
Units	Woodland	Cropland	Gasconaue Rating
Upper Gasconade Riv	ver	.,	
-010001	35.53	9.62	59.00
-010002	45.55	6.76	72.18
-010003	34.08	10.57	56.60
-010004	38.52	6.06	65.75
-010005	38.49	9.28	32.47
-010006	43.30	6.11	70.20
		Average	59.36
Beaver Creek	1	,,	
-020001	32.34	6.02	59.45
-020002	49.54	5.75	77.30
		Average	68.37
Upper Osage Fork		1	
-030001	37.94		64.00
-030002	42.03	7.37	68.00
-030003	38.03	9.05	62.20
-030004	46.32	7.71	71.95
-030005	30.63	15.81	47.80
-030006	36.90	17.69	52.20
		Average	61.02
Lower Osage Fork	1	,	
-040001	45.95	7.77	71.30
-040002	29.16	12.75	49.30
-040003	53.48	7.20	78.80
,		Average	66.46
Upper Gasconade River Tr	ributaries	,	
-050001	43.59	5.97	70.90
-050002	45.39	6.47	72.20
-050003	61.61	4.50	90.80
-050004	64.12	6.14	91.75

-050005	68.84	3.93	98.95
		Average	84.92
Roubidoux Creek			
-060001	50.15	8.89	74.70
-060002	66.70	4.66	95.90
-060003	58.88	24.13	68.10
-060004	31.31	62.37	0.40
-060005	29.31	57.42	3.99
		Average	48.62
Middle Gasconade River			
-070001	45.35	10.53	68.10
-070002	64.37	4.72	93.40
-070003	54.53	8.58	78.90
-070004	63.79	7.20	90.26
-070005	69.62	4.80	98.90
		Average	85.91

Table 23. Impacted 14-digit hydrologic units within the Lower Gasconade River watershed (HUC # 10290203-) determined using Phase II Land Use / Land Cover MORAP 30-meter resolution satellite imagery. Ratings from 0 (most) to 100 (least) impacted. Gasconade rating rates the % LULC classes according to a derived the high and low range.

14-digit Hydrologic Units	% Forest & Woodland	% Urban & Cropland	Gasconade Rating
Lower Gasconade River	Hills		
-040005	72.961	5.985	83.10
-040004	57.63	15.64	2.50
-040003	71.753	6.886	79.95
-040002	67.363	8.325	68.00
-040001	58.867	6.057	31.10
I.		Average	52.93
Third Creek		2	
-030001	67.672	8.435	69.30
-030002	64.21	4.615	60.30
,,		Average	64.80
Lower Gasconade River	ŗ	1	
-020007	53.185	6.57	14.60
-020006	63.319	7.982	37.10
-020005	71.304	7.3	78.70
-020004	63.16	8.76	57.40
-020003	57.241	13.539	7.10
-020002	67.234	6.27	68.25
-020001	69.307	3.62	73.60
-		Average	48.11
Little Piney Creek	'	1	
-010004	68.659	6.438	72.10
-010005	73.954	10.509	85.70
-010003	82.614	2.831	99.90
-010002	67.986	6.471	70.10
-010001	59.891	10.126	22.72
		Average	70.10

Table 24. Cross-reference of wetland classification systems. Taken from Epperson (1992).

Missouri Wetland Types	SCS Food Security Act	Missouri Natural Terrestrial Communities	Cowardin et al.
1. Swamp	Wetland (Wetland Wooded or Wetland Forested)	Swamp Ponded Swamp	Palustrine Forested Wetland
2. Shrub Swamp	Wetland (Wetland Shrub)	Shrub Swamp Pond Shrub Swamp	Palustrine Scrub-shrub Wetland
3. Forested Wetland	Wetland (Wetland Wooded or Wetland Forested)	Mesic Bottomland Forest (in part) Wet Mesic Bottomland Forest Wet Bottomland Forest Flat Woods (in part) Wet-Mesic Savanna	Palustrine Forested Wetland
4. Marsh	Wetland	Freshwater Marsh Saline Marsh Pond Marsh	Palustrine Emergent Wetland, Lacustrine Emergent Wetland, Riverine Emergent Wetland
5. Wet Meadow	Wetland Wetland Pasture	Wet-Mesic Prairie Wet Prairie	Palustrine Emergent Marsh
6. Fens and Seeps	Wetland	Fen, Deep muck fen, Prairie fen, Forested fen, Seep, Acid seep, Forested acid seep, Saline seep	Palustrine Emergent Marsh

7. Natural Ponds and Lakes	Wetland (Wetland Open Water) (Wetland Emergent)	N/A	Palustrine Open Water Wetland, Palustrine Unconsolidated Bottom Wetland, Palustrine Aquatic Bed Wetland, Lacustrine Littoral Wetland
8. Streams	Wetland (Open Water)	Sandbar, Gravelwash	Riverine Upper Perennial, Riverine Lower Perennial, Riverine Intermittent Stream

Table 25. Percentage of total wetland acres for each wetland systems/classes and description within the Gasconade River watershed.

Cowardin Wetland System/Class	Description	Total Acres	% of total acres
Upper Gasconade River watershed (#10290201)			
Total Lacustrine			
	Lake/Reservoir	69.64	0.63
Total Palustrine		609.3	5.49
Total Aquatic Bed		27.99	0.25
Total Deciduous Bottomland Forest		513.13	4.63
Total Scrub Shrub		68.18	0.61
Total Emergent		364.19	3.28
	Upland Marsh or Fen	11.06	0.10
	Wet meadow or flat	137.40	1.24
	Shallow marsh	172.82	1.56
	Deep marsh	42.91	0.39
Total Unconsolidated Bottom		3806.39	34.33
	Pond	99.49	0.90

	Drained waterbody	7.57	0.07
	Excavated pond	121.75	1.10
	Farm pond	3577.58	32.26
Total Riverine		5874.77	52.98
	Gravel bar	919.73	8.29
	Permanent pool	38.46	0.35
	Pool/riffle complex	3221.97	29.06
	Sand flat or gravel flat	11.75	0.11
	Temporary pool	274.94	2.48
	Temporary-semipermanent pool	1407.92	12.70
Total Wetland Polygons		11088.48	100.00
Lower Gasconade River watershed (#10290203)			
Total Lacustrine			
	Lake/Reservoir	429.19	6.07

Total Palustrine		3043.17	43
Total Aquatic Bed		9.36	0.13
Total Deciduous Bottomland Forest		3000.56	42.40
Total Scrub Shrub		33.25	0.47
Total Emergent		483.33	6.62
	Upland Marsh or Fen	17.55	0.25
	Wet meadow or flat	316.17	4.47
	Shallow marsh	134.80	1.90
	Deep marsh	14.81	0.21
Total Unconsolidated Bottom		2247.3	31.75
	Excavated pond	175.83	2.48
	Pond	73.71	1.04
	Farm pond	1997.76	28.23
Total Riverine		873.44	12.34
	Permanent pool	54.43	0.77
	Sand flat or gravel flat	3.53	0.05

	Excavated channel	15.37	0.22
	Temporary pool	8.02	0.11
	Temporary-semipermanent pool	312.80	4.42
	Vegetated Island bar	12.99	0.18
	Gravel bar	466.30	6.59
Total Wetland Polygons		7076.42	100.00

Table 26. Percentage gravel bars acreage per 11-digit hydrologic unit (HU) area within the Gasconade River watershed.

Wetland System/Description	Acres	% gravel bar acres/HU acres	% of total wetlands in HU
Upper Gasconade River	61.17	0.041	4.25
epper Gasconauc River	01.17	0.041	T.23
Upper Gasconade River Tributaries	224.26	0.149	15.63
Roubidoux Creek	65.90	0.036	5.34
Beaver Creek	60.29	0.071	9.07
Middle Gasconade River	136.47	0.088	4.41
Upper Osage Fork	274.35	0.128	17.01
Lower Osage Fork	98.13	0.090	7.87
Lower Gasconade River	178.93	0.081	9.99
Little Piney Creek	43.69	0.023	5.30
Lower Gasconade River Hills	146.72	0.077	3.95
Third Creek	96.96	0.149	12.98